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SEMI-INTENSIVE SHRIMP FARMING SYSTEM OF KERALA, INDIA: A PRODUCTION FUNCTION ANALYSIS

M. S. Raju
College of Fisheries, Panangad Kochi - 682 506

ABSTRACT

An analysis of the factor-product relationship in the semi-intensive shrimp farming system of Kerala, farm basis and hectare basis, we are attempted and the results reported in this paper. The Cobb-Douglas model, in which the physical relationship between input and output is estimated, and the marginal analysis then employed to evaluate the producer behaviour, was used for the analysis. The study was based on empirical data collected during November 1994 to May 1996, covering three seasons, from 21 farms spread over Alappuzha, Ernakulam, and Kasaragod districts of the state. The sample covered a total area of 61.06 ha. Of the 11 explanatory variables considered in the model, the size of the farm, casual labour and chemical fertilizers were found statistically significant. It was also observed that the factors such as age of pond, experience of the farmer, feed, miscellaneous costs, number of seed stocked and skilled labour contributed positively to the output. The estimated industry production function exhibited unitary economies of scale. The estimated mean output was 3937 kg/ha. The test of multi-co-linerity showed that there is no problem of dominant variable. On the basis of the marginal product and the given input-output prices, the optimum amounts of seed, feed and casual labour were estimated. They were about 97139 seed, 959 kg of feed and 585 man-days of casual labour per farm. This indicated the need for reducing the stocking density and amount of feed from the present levels, in order to maximise profit. Based on the finding of the study, suggestions for improving the industry production function are proposed.

Keywords : Semi-intensive shrimp farming, production function, factor product relationship, optimum level of input, economic of scale

INTRODUCTION

The scientific and technological advancements in shrimp aquaculture have made it one of the promising industries of India in recent years. In the course of time, shrimp farming took strides in the state of Kerala, from 'traditional' practices to 'modified traditional', 'extensive' and further to 'semi-intensive' farming systems. The big profit in commercial shrimp farming attracted a lot of investors to this sector.

Ultimately, brackishwater aquaculture became a synonym of brackishwater shrimp farming in Kerala. The short harvesting cycle and the excellent rate of return ensured by the ever-growing demand for shrimp in the world markets were the important reasons behind the rush towards shrimp farming. Shrimp aquaculture has been well recognised as a source of food, income, employment and foreign exchange.

Understanding the great potential of semi-intensive shrimp farming, a lot of enterprising farmers in Kerala also ventured into this sector. These shrimp farms are shallow impoundments, which are utilised for culture on scientific lines involving advanced techniques so that higher dozes of inputs are applied to increase the productivity. The semi-intensive shrimp farms are capital-intensive and require higher initial investment. Under this system, extra care is taken in the selection, location, design and preparation of farms, seed, stocking density, fertilisation, feeding (with formulated feeds), aeration, harvesting, marketing, etc. Compared to extensive farms, more controls at different stages of production could be possible under semi-intensive farming.

Hirasava (1985) pointed out that by adopting semi-intensive farming, shrimp can be produced at low costs compared to extensive system of farming. Highlighting the importance of semi-intensive farming, Lippert (1990) observed that "the search for efficient operating levels has taken the farmer operating with extensive system to semi-intensive systems. Similarly, the intensive farmer has shifted to semi-intensive systems. The end result is more consistent production with less risk".

The area under semi-intensive shrimp farms in Kerala is only less than 5% (about 500 ha) of the total area under culture. The productivity of these farms ranges between 2000 and 4000 kg/ha per crop (estimated by the author). The recommended stocking rate under the system ranges between 100,000 and 300,000 seed (Velayudhan, 1996).

The paucity of reliable economic information on aquaculture is felt all over the world. To quote Pillay (1990), "despite the basic importance of economic viability, very little attention has been paid to this aspect, and promotion of aquaculture has suffered considerably for lack of appropriate data and documentation on relevant evaluation."

The present study an attempt to explore the production function in the semi-intensive aquaculture system of Kerala and to fill the information gap to some extent.

MATERIAL AND METHODS

To understand the dynamics of aquaculture production, a production function study was made by estimating the total and marginal relationship between output and a number of explanatory variables. The methodology used to estimate the production function(s) was basically drawn from the neo-classical economic theory. According to the theory, the physical relationship between input and output is estimated and then marginal analysis is employed to evaluate producer behaviour. Such studies are widely undertaken in economics, using empirical data on agriculture and industry following the pioneering work of Cobb and Douglas (1928). The application of this method for estimating agriculture production function was described by Lave (1962), Griliches (1963), Garrod and Aslam (1977), and others. The Cobb-Douglas function and its application in estimating aquaculture production function is stated by Shang (1981, 1990) and Smith (1982).

The Cobb-Douglas model (Heathfield and Wibe, 1987) was adopted in the present study for the estimation of input-output relationship of different aquaculture systems of Kerala. The log-linear form of Cobb-Douglas function is

$Y = AX_1^{\beta 1}X_2^{\beta 2}\,.........X_n^{\beta n}$, is
$\log Y = \log A + \beta_1 \log X_1 + \beta_2 \log X_2 ..... + \beta_n \log X_n$
(where, Y = output; X_1, X_2......, X_n = inputs; β_1, β_2.........., β_n = factor productivity).

The production function is estimated using the ordinary least square method by considering the logarithmic transformation of the production function.

The Cobb-Douglas model is widely used in aquaculture economics all over the world to explain the dynamics of aquaculture production. The results of some such studies are recorded by Chong and Lizarondo (1982), Wattanutchariya and Panayoton (1982), Ranadhir (1985), Rajasenan (1987), Ajithkumar (1990), and Ranadhir and Tripathi (1991).

It should also be noted here that the farm-basis production function proposed to be estimated is the industry function in so much as it portrays an average input-output relationship for all the farms in the industry.

Database

The study was mainly based on empirical data collected from field surveys conducted during November 1994 to May 1996 in different districts of Kerala. The Marine Products Export Development Authority (MPEDA), the brackishwater fish farmers development agencies and other agencies concerned of the chosen districts were approached for the primary identification of shrimp farmers. Subsequently, samples were chosen from among the identified population by adopting the random sampling technique and the data were collected using pre-tested questionnaires. The 1995 price structure was followed for the analysis.

The production function analysis of the semi-intensive shrimp farming system of Kerala is based on information gathered from 21 farms. These farms are located in Alappuzha (20%), Ernakulam (38%), Kannur (18%) and Kasargod (24%) districts. The total area of farm was 61.06 ha represented by Alappuzha (11.21 ha), Ernakulam (22.20 ha), Kannur (13.99 ha) and Kasaragod (13.66 ha) districts. It should also be noted here that since the available sample size was small, the estimated industry function should be used cautiously while making generalisations.

RESULTS AND DISCUSSION

Socio-economic profile of the sample farms

The general information gathered from the semi-intensive farms relates to the location of the farms, major occupation of the farmers, their educational status, ownership pattern, source of seed, species stocked, marketing outlets etc.

It was observed that majority of the semi-intensive shrimp farmers of the state were businessmen (42.86%), followed by professionals (23.81%) and agriculturists (19.05%). The educational status of the farmers showed that most of them were college educated (57.14%). It was also found that under the semi-intensive system, only 7.52% of the sample farms are leased. All these factors indicated a remarkable change compared to the occupational and educational status of farmers engaged in other systems of shrimp farming in Kerala (Raju, 1997).

It was observed that 76.19% of the semi-intensive farms are stocked with high priced *Penaeus monodon* seed and the rest (23.81%) a combination of *P. indicus* and *P. monodon*. It was also observed that all the farms were stocked with hatchery seed where majority ventured for a single crop.

The total cost of production per hectare was worked out to be Rs 164,149. The cost items were: feed (26.95%), seed (23.63%), depreciation (13.06%), interest (12.92%), salary (9.17%), fuel and power (4.53%), casual labour (2.58%), land lease (2.27%) and miscellaneous (4.89%).

It was observed that the important problems faced at the semi-intensive farms were the shortage of desired species of seed, lack of finance, etc. The heavy capital investment and higher operating cost of these farms increased the risk of farming under the system. Absence of required technical support and insurance coverage, and outbreak of disease further aggravate the burden of the farmers. Moreover, the farmers were found to have experienced the challenges from the public against intensive shrimp farming.

The study revealed that 95.24% of the farmers sold their produce directly to shrimp processors after negotiating the prices. The rest of the farmers sold their produce to the retailers.

Input-output relationship in the semi-intensive shrimp farming system of Kerala

The factor-product relationship of the semi-intensive shrimp farming system of Kerala has been estimated with the help of 11 explanatory variables. The inputs specified for the estimation were the age of the ponds (AGE), the area of farm (AREA), casual labour (CL), distance of farm from the bar-mouth (DISTA), experience of the farm operator (EXPE), feed (FEED), fertiliser (FERT), fuel and power expenses (FP), seed stocked (SEED), skilled workers (SK-PER) and miscellaneous costs (MISC). The mean and standard deviation of the chosen variables in their raw, normalised and lognormal forms are presented in Table 1.

The envisaged production function model explains the variation in shrimp output within the limits of these explanatory variables. To evaluate the relative influence of each of the 11 variables in the shrimp output, the Cobb-Douglas model was used. The parameters were estimated using multiple regression techniques.

The following Cobb-Douglas production function was used for the estimation:

$$Y = a_0 X_1^{\beta 1} X_2^{\beta 2} X_3^{\beta 3} X_4^{\beta 4} X_5^{\beta 5} X_6^{\beta 6} X_7^{\beta 7} X_8^{\beta 8} X_9^{\beta 9} X_{10}^{\beta 10} X_{11}^{\beta 11}$$

Normalised data are considered for the estimation of the parameters, a_0, $\beta_1 \ldots \beta_{11}$. The transformed equation of the original Cobb-Douglas model is:

$$\log Y = \log a_0 + \beta_1 \log X_2 + \beta_2 \log X_3 + \beta_3 \log X_4 + \beta_4 \log X_4 + \beta_5 \log X_5 + \beta_6 \log X_6 + \beta_7 \log X_7 + \beta_8 \log X_8 + \beta_9 \log X_9 + \beta_{10} \log X_{10} + \beta_{11} \log X_{11}$$

Where Y = output of shrimp (kg); X_1 = age of pond (year); X_2 = size of the farm (ha); X_3 = casual labour (man-h); X_4 = distance of the farm from the bar-mouth (km); X_5 = experience of the farm operator (yr); X_6 = feed (kg); X_7 = chemical fertilitisers (kg); X_8 = fuel and power (Rs); X_9 = miscellaneous costs (Rs); X_{10} = seed stocked (no.); X_{11} = skilled workers (man-h), and a_0 and β_1 = parameters to be estimated.

Estimated production function

Two basic production functions of the semi-intensive shrimp farms were estimated: on the farm basis and hectare basis. In order to facilitate the latter, the relevant data fields were standardised accordingly. The microeconomics of the production function in the semi-intensive shrimp farms of Kerala is explored and the findings are stated.

The results of the estimates of the production functions (farm basis and hectare basis), are presented in tables 2 and 3, respectively. The estimated values of the exponents, the intercept, their standard error, the coeffcient of determination, the T-values and their significance levels, the F-values, the sample input means, the estimated output at X, the marginal products, etc. are recorded in

Table 1 : Mean and standard deviation of the explanatory variables in their various forms

Sl.no.	Variables	Primary data		Normalised data		Log (normalised data)	
		Mean	SD	Mean	SD	Mean	SD
1.	AGE	5.62	2.67	2.15	1.02	0.65	0.51
2.	AREA	2.93	2.61	1.14	1.02	-0.26	0.93
3.	CL	1284.43	3026.45	0.43	1.02	-1.54	0.90
4.	DISTA	10.50	7.09	1.45	1.02	-0.01	1.04
5.	EXPE	4.24	2.76	1.58	1.02	0.25	0.68
6.	FEED	4495.86	6163.86	0.75	1.02	-0.71	0.84
7.	FERT	142.19	241.09	0.60	1.02	-2.58	3.47
8.	FP	23209.05	36838.65	0.65	1.02	-1.31	1.57
9.	MISC	3841.43	2565.37	1.18	1.02	-0.19	0.89
10.	SEED	294603.00	354294.16	0.85	1.02	-0.74	1.08
11.	SK-PER	3291.43	2328.30	1.14	1.02	-0.55	2.91

the tables. The exponents of the specified inputs are reported along with their statistical significance.

Production function - farm basis

The estimated production function of the semi-intensive shrimp farming system of Kerala on farm basis is presented in Equation-1 (Table 2).

$$Y_F = 0.865X_1^{0.077}X_2^{0.259}X_3^{0.204}X_4^{-0.129}X_5^{0.214}X_6^{0.053}X_7^{0.079}X_8^{-0.002}X_9^{0.139}X_{10}^{0.070}X_{11}^{0.032}$$

[Equation-1]

The estimated production revealed that of the 11 explanatory variables chosen for the estimation, three were statistically significant at small probability levels (Table 2). These inputs were the size of the farm (X_2), casual labour (X_3) and chemical fertilizers (X_7). The other variables found to be positively contributing to the total shrimp output are the age of pond (X_2), experience (X_5), feed (X_6), miscellaneous costs (X_9), seed (X_{10}) and skilled labour (X_{11}). The contribution of inputs such as distance (X_4), and fuel and power (X_8) are observed to be inversely proportional to the output.

An analysis of the transformation ratios of the various inputs shows that the major contribution towards the output are: the size of the farm (one-fourth of the output), followed by experience and casual labour (one-fifth each). All the positive values of the exponents are observed to be consistent with the theory and logic.

The co-efficient of determination of the estimated function (Equation-1) is 95%. The F-value (15.45) is significant at 1% level. The value of the constant (0.865) indicates lack of technical efficiency.

Economics of scale:

The sum of the values of the exponents $\Sigma\beta_i$ = 0.996 (Equation-1) indicate that almost unitary economics of scale have been prevailing under the system. Accordingly, a doubling of all specified inputs in the function could double the output also.

Production function - hectare basis

The tectare-basis estimated production function of the semi-intensive shrimp farming system is given in Equation-2.

$$Y_H = 0.952X_1^{0.295}X_3^{0.128}X_4^{-0.127}X_5^{0.319}X_6^{0.324}X_7^{-0.178}X_8^{0.060}X_9^{0.371}X_{10}^{0.080}X_{11}^{-0.009}$$

[Equation-2]

The estimated function (Equation-2) showed that similar to the industry production function (Equation-1), three of the 10 explanatory variables chosen are statistically significant at low probability levles (Table-3). These inputs are feed (X_6), fertiliser (X_7) and miscellaneous costs (X_9). The inputs such as age of pond (X_1), casual labour (X_3), experience (X_5), fuel and power (X_8), seed (X_8), feed (X_{10}), etc. were found to be positively contributing towards the shrimp output. However, the contribution of variables like distance (X_4), chemical fertiliser (X_7) and skilled workers (X_{11}) are observed to be inversely proportional to output. The contribution of skilled workers appeared inverse because, in the derived

Table 2 : Estimated production function, sample means and estimated output and marginal product for semi-intensive shrimp farming system of Kerala (farm basis)

	AGE X_1	AREA X_2	CL X_3	DISTA X_4	EXPE X_5	FEED X_6	FERT X_7	F-P X_8	MISC X_9	SEED X_{10}	SK-PER X_{11}
Intercept 0.865											
Production coefficients		0.077	0.259	0.204	0.214	0.053	0.079	-0.002	0.139	0.070	0.032
t-Value	0.427	1.914	1.953	-1.170	1.343	0.381	2.777	-0.025	1.123	0.638	1.061
Standard error	0.181	0.135	0.104	0.110	0.159	0.138	0.028	0.086	0.124	0.110	0.030
Significance level	0.680	0.088	0.083	0.272	0.212	0.712	0.023	0.980	0.290	0.540	0.316
R^2	95										
F - Value 15.45**											
Input mean(X)											
GM	5.01	1.98	631.12	6.84	3.46	2968.48	36.56	9662.43	2073.09	1654.30	1505.83
AM	5.62	2.93	1284.43	10.50	4.24	4495.86	142.19	23209.05	3841.43	294603.00	3291.43
Estimated output at X= 11534.05											
Marginal product	1.15	9.79	0.02	-1.41	4.63	0.001	0.16	-0.00002	0.01	0.00003	0.002
Average cost of input (Rs)			9.68/h			29.03/kg	5.76/kg			0.39/seed	

GM = Geometric mean; AM = Arthmetic mean ** Significant at one per cent level

Table 3 : Estimated production function (C-D), sample means and estimated output and marginal product for semi-intensive shrimp farming system of Kerala on hacture basis.

		AGE X_1	AREA X_2	CL X_3	DISTA X_4	EXPE X_5	FEED X_6	FERT X_7	F-P X_8	MISC X_9	SEED X_{10}	SK-PER X_{11}
Intercept	0.952											
Production coefficients		0.295		0.128	-0.127	0.319	0.324	-0.178	0.060	0.371	0.080	-0.009
t-Value		1.372		1.045	-1.167	1.470	1.739	-1.703	0.677	3.312	0.616	-0.072
Standard error		0.215		0.122	0.109	0.217	0.187	0.104	0.088	0.112	0.129	0.125
Significance level		0.200		0.320	0.270	0.172	0.113	0.120	0.514	0.008	0.552	0.944
R^2	95											
F - Value	14.99**											
Input mean(X)												
GM		5.01		252.45	6.84	3.46	1187.37	14.62	3864.93	2073.09	66172.00	462.29
AM		5.62		1284.43	10.50	4.24	4495.86	142.19	23209.05	2965.24	294603.00	140.68
Estimated output at X=												
Marginal product		84.070		0.720	-26.510	131.600	0.390	-17.380	0.020	0.260	0.002	-0.030
Average cost of input (Rs)												

GM = Geometric mean; AM = Arthmetic mean ** Significant at one per cent level per hectare function, its use is below the standard minimum doze.

The coefficient of determination of the estimated function (Equation-2) is about 94% and the F-value (14.99) is significant at 1% level. Further, the low value of the constant indicates low technical efficiency.

The sum of the values of the coefficients of hectare basis production function (1.26) exhibits increasing returns to scale. It means that if all the specified variables are increased by 1%, the output will increase by 1.26%.

Nature of input-output response

The study reveals that the yield under the semi-intensive system is greatly influenced by the specified explanatory variables. This is substantial by the fact that the 11 variables chosen for the models explained 94 to 95% of the variation in the shrimp yield.

The negative production coefficient and marginal physical product of the respective inputs implies that a reduction in the volume of these will enhance the efficiency of the system and *vice versa*.

The R^2 values and the F-values of the estimated production function (Table 2 - 3) substantiate that the Cobb-Douglas model fitted the data well. the F-values were significant at 1% level. The R^2 values (ranging between 94 and 95%) are also statistically significant. Finally, co-linearity diagnosis revealed that the data are not met with the problem of dominant variables or multi co-linearity. This can also be observed from the correlation matrix of the explanatory variables appended in Table 4.

Value of marginal product and optimum input use

The farmers under the semi-intensive system enjoyed greater control over various inputs compared to the other systems of shrimp farming. Therefore, the determination of the optimum level inputs is of great practical importance. The optimum input levels of the semi-intensive farming system were derived from the estimated industry production function (Equation-1) with the help of the geometric means of all other inputs and the input-output prices.

Optimum stocking rate

The marginal product of seed obtained by taking partial derivative of the industry production function (Equation-1) with respect of seed (X^{10}) yields:

$$dy/dx_{10}=0.99\ X_1^{0.077}X_2^{0.259}X_3^{0.204}$$

$$X_4^{-0.129}X_5^{0.214}X_6^{0.053}X_7^{\ 0.079}$$

$$X_{8-}^{\ 0.002}X_9^{0.139}X_{10}^{-0.930}X_{11}^{0.032}$$

Equating this with the input-output price ratio* (0.39/281.36)=0.0014, then

$$0.99\ X_1^{0.077}X_2^{0.259}X_3^{0.204}$$

$$X_4^{-0.129}X_5^{0.214}X_6^{0.053}X_7^{\ 0.079}$$

$$X_{8-}^{\ 0.002}X_9^{0.139}X_{10}^{-0.930}X_{11}^{0.032}=0.0014$$

Solving for X_{10}:

$$X_{10}^{-0.930}(0.99)(1.13)(1.19)(3.73)$$
$$(1.28)(1.30)(1.53)(1.33)(0.98)(2.89)(1.26)=0.0014$$

$$60X_{10}^{-0.930} = 0.0014 = 0.000023$$

Therefore, X_{10}= 97139 seed.

* Based on the cost of seed (Rs 0.39) and the price of shrimp (Rs 281.36/kg)

Table 4 : Correlation matrix of the explanatory variables of semi-intensive shrimp farming system of Kerala

	AGE	AREA	CL	DISTA	DEPTH	EXPE	FEED	FERT	F-P	MISC	SEED	SK-PER
AGE	1.0000											
AREA	0.3506	1.0000										
CL	-0.2655	0.3788	1.0000									
DISTA	-0.2450	-0.2758	0.0310	1.0000								
DEPTH	-0.4249	-0.4897	0.2763	0.0662	1.0000							
EXPE	-0.2214	0.2291	0.1268	0.1469	-0.2203	1.0000						
FEED	-0.1514	0.1733	0.5528	0.3081	0.1991	-0.2788	1.0000					
FERT	0.0508	0.0190	0.0625	0.2704	0.1234	0.0135	0.4367	1.0000				
FP	-0.0557	-0.1704	0.2480	0.4215	0.2212	0.2159	0.4091	0.5075	1.0000			
MISC	0.1047	0.1093	0.2146	0.3384	-0.0833	0.1650	0.3428	0.3548	-0.0661	1.0000		
SEED	0.0333	0.3907	0.3289	0.0110	0.0190	0.3557	0.4071	0.5722	0.6319	0.1313	1.0000	
SK_PER	0.0278	-0.0867	0.2771	0.2827	0.1594	-0.0065	0.2947	0.2364	0.6294	-0.0566	0.3589	1.0000

This means that the optimum stocking rate of an average farm under the semi-intensive system is about 97139 seed.

If this optimum stocking rate is compared with the arithmetic and geometric means of the actual stocking rate (294603 and 165430, respectively), it is apparent that the average shrimp farmer under the system in Kerala would gain in terms of profit by decreasing the stocking rate.

Optimum feed

Given that the average cost of feed per kilogramme is Rs. 29.03, the optimum quantity of feed (X_6) under the system is 959.30 kg. This is also beacuse:

$dY/dX_6 = PX_6/Py = 0.103$ in Equation 1 yields:

$$65.88X_6^{-0.947} = 0.103$$

$X_6^{-0.947} = 0.103/65.88 = 0.0016$. Therefore, $X_6 = 896.10$ kg.

Comparing this quantity with the geometric and arithmetic means of the actual feed use (2968.48 and 4495.86, respectively), it is obvious that they are remarkably high. In other words, this means that an average farm under the semi-intensive system of shrimp farming will be able to maintain the present output levels even by decreasing feed levels down to 896.10 kg along with decreased stocking rates. The finding suggests the use of a lesser quantity of formulated feed. It is consistent with the earlier observation suggesting a decrease in the stocking rate in the farms under the semi-intensive system.

Optimum amount of casual labour

The equality between the marginal product of casual labour (dy/dX_3) and the price ratio** (PX_3/Py) in Equation-1 yields:

$$26.48\, X_3^{-0.796} = 0.033$$

This means that the maximum profitable level of casual labour in a semi-intensive farm would be 4670.57 man-h or about 584.8 man-d. This suggests that under the existing system, the casual labourers are under employed to the extent of the difference between its means and the optimum quantity. Therefore, a reduction in the amount of casual labour will reduce the cost.

Estimated output

The derived output of the semi-intensive farms of Kerala from the industry production function (Equation-1) at the geometric means of the inputs is 11534.05 kg per farm which is 3936.54 kg/ha. It means that by applying input at the means, the semi-intensive shrimp farmers in the state could harvest output at 3936.54 kg/ha. In reality, a large majority of the semi-intensive shrimp farmers applied inputs far below the average and hence, the production realised by them are as low as 1027.83 kg/ha.

Conclusion

The factor-product relationship in the semi-intensive shrimp farming system of Kerala has been revealed from the estimated intra-farm production function, (Equation-1). The estimated function showed that by changing the factor balances, the yield of

** Based on the wage rate of labour Rs 9.37/man-h the farms under the system can be enhanced up to about 4000 kg/ha from the present level of 1027.83 kg/ha. In other words, it means that the present yield could be obtained from an area of 0.26 ha. It also implies that the semi-intensive shrimp farms of Kerala have the potential of enhancing their output four-fold through better resource management. The low constant values in the equations 1 and 2 point towards the technical inefficiency of the prevailing system of semi-intensive shrimp farming in the state. However, the semi-intensive shrimp farming system of Kerala offers a promising area for profitable investment and sustainable aquaculture.

The production function analysis also indicated that of the 11 inputs chosen to explain the production function under the semi-intensive system of shrimp farming, age of pond, amount of feed, seed, chemical fertilisers, etc. are found to have a significant impact on output. The value of R^2 of the function is 0.94 and the F-value (15.45) is significant at 1.% level. The study also revealed that unitary economies of scale exist under this shrimp farming system.

Recommendations

For overcoming some of the major problems noted in the semi-intensive shrimp farming system in the state, the following recommendations are presented

The semi-intensive system of shrimp farming should be maintained considering its commercial importance. However, appropriate regulations should be introduced to make it eco-friendly.

The stocking rate of the farms under the semi-intensive systems may be limited to the range of 70,000-120,000/ha depending upon the species stocked in order to realise better returns.

According to the given input-output price ratio, after adopting optimal stocking rate, the feeding levels under the semi-intensive system may be reduced. The semi-intensive farms may gain by reducing the feed to less than one-third of the present level. The semi-intensive farms can also gain by substituting the costly formulated feed with some locally available low-cost feeds.

The risk under the extensive and semi-intensive shrimp farming systems arising out of the high capital and variable costs may be insured against. The insurance companies are now seen withdrawing from this sector. Under this circumstance, the Government may cover the risk by planning insurance-linked credit schemes. The funds for insurance coverage may be found from the subsidy component of the existing finance schemes.

The techno-economic efficiency of the farming system may be improved by employing technically qualified personnel. The Government can also greatly involve in this by strengthening the education and extension wings, and by imparting technology and training wherever necessary.

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